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PATENT SPECIFICATION

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(54) SPHEROIDAL CAST-IRON ALLOY OF INCREASED WEAR RESISTANCE

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GOETZE A.G., a Body Corporate organised
under the laws of the Federal Republic of
Germany, of Bürgermeister-Schmidt-Strasse
17, 5673 Burscheid, Germany, do hereby de-
clare the invention and the method by which
it is to be performed, to be particularly de-
scribed in and by the following statement:—

The invention concerns a cast-iron alloy
having increased wear resistance, containing
spheroidal graphite precipitates and having a
carbon content in the limits of 2.5—4.5 per
cent by weight, a silicon content in the limits
of 1.5—4.5 per cent by weight and a sulphur
content below 0.1 per cent by weight.

Mechanically highly-stressed machine parts,
such as for example piston rings for internal
combustion engines, besides having a definite
minimum strength and toughness, must in
addition, being frictionally-stressed machine
parts, also have high wear resistance. Cast-
iron alloys with spheroidal graphite precipi-
tates of the usual composition possess good
strength and toughness, so that for example
piston rings made of this material do not
fracture and are very suitable for use. The
wear resistance of these materials, however, is
very low, so that the running surfaces and
flanks have to be protected additionally by
coatings, this being done by chromium electro-
plating, a process which, for example, con-
siderably increased the cost of manufacturing
the piston rings.

The deficient wear resistance of cast-iron
materials having spheroidal graphite precipi-
tates of the usual composition is to be attri-

buted to the absence of a steadite net as sup-
porting structure in the matrix of the material.
All attempts to optimise the phosphorus con-
tent in such a way that sufficient phosphorus
was added for a definite steadite content to be
present but which had no harmful influence on
the strength, have failed because the steadite
phase, even in very small amount, has a very
deleterious influence. This is probably to be
attributed to the fact that this phase cannot
be made to crystallise in such a fine form
uniformly distributed in the matrix of the
material.

In accordance with the present invention
there is provided a wear-resistant spheroidal-
graphite cast iron alloy having the following
composition:—

	per cent by weight	
Carbon	2.5 —4.5	
Silicon	1.5 —4.5	
Sulphur below	0.1	
Manganese	0.5 —1.7	
Phosphorus	0.06—0.5	60
Chromium	0.2 —0.8	
Vanadium	0.1 —2.5	
Nickel	0.2 —0.8	
Copper	0.2 —1.8	
Titanium	0.1 —0.8	65
Tungsten	0.2 —2.0	
Tin	0.05—1.0	
Magnesium	0.02—0.5	
Molybdenum	0.2 —2.0	
Niobium	0.2 —2.0	70
Remainder	iron	

With this composition, phases are produced in the structure which act like steady for wear resistance but also have a very small spherical formation which has no more detrimental effect on the strength than the spheroids themselves.

The alloy can be produced by inoculation of the melt with ferrosilicon in conventional manner followed by addition of magnesium in elementary or alloyed form. This results in the presence of almost the desired number and form of spheroids in the cast alloy. The phosphorus which can surprisingly be in an amount of up to 0.5 per cent by weight, separates out in phosphorus-containing phases which scarcely have any detrimental effect on the strength.

It has furthermore been found that for refining the individual micro structural constituents, the elements antimony, boron, zirconium and bismuth or also the rare-earth metals may be added, but the sum of these elements must altogether be not more than 0.5 per cent by weight.

It has also been found that by heat treatment, such as for example by annealing above 700°C, followed by quenching and subsequent tempering at temperatures which may be between 200 and 700°C, further improvements can be obtained with regard strength and above all wear resistance.

The alloys according to the invention have a bainitic to martensitic matrix structure. The graphite precipitates are spheroidal and the wear-resistant carbide precipitates are punctiform to spherical and form small crystals. The hardness of these alloys lies between HB 250 and HB 500 kg/cm². Tensile strengths, bending strengths, elastic modulus and wear resistance in the cast piston rings are so good that coating of the running surface with wear-resistant materials is unnecessary.

The cast-iron alloy according to the invention is represented in the following example:—

The cast-iron melt contains as alloying constituents:

3.26 per cent by weight of carbon
2.48 per cent by weight of silicon
1.29 per cent by weight of manganese
0.12 per cent by weight of phosphorus
0.04 per cent by weight of sulphur
0.63 per cent by weight of chromium
0.23 per cent by weight of vanadium
0.54 per cent by weight of nickel
1.16 per cent by weight of copper
0.5 per cent by weight of titanium
0.62 per cent by weight of tungsten
0.14 per cent by weight of tin
0.42 per cent by weight of molybdenum
0.64 per cent by weight of niobium

After inoculation with ferrosilicon, the spheroidal graphite precipitates are produced

by the addition of magnesium in an amount of 0.4 per cent by weight referred to the total quantity, using a suitable device for this purpose. Then, by means of the sand mould method, piston rings are made therefrom with the dimensions 120 mm. external diameter, width 5 mm. and thickness 3 mm. They are then annealed above 700°C, air-quenched and tempered at 550°C.

The piston rings thus made have a Brinell hardness of between 394 and 438 kg/mm², and an elastic modulus of 16,340—17,880 kg/mm².

In test runs, the piston ring flanks showed a wear resistance 1½ to 2 times greater than hitherto used normal spheroidal cast-iron alloys. The unprotected running surfaces also showed in test runs an excellent wear resistance.

Figures 1 to 3 show photomicrographs of the cast iron according to the example.

Photomicrograph 1, magnification ×100, shows the spheroidal graphite precipitates.

Photomicrograph 2, magnification ×500, shows in addition to the dark spheroidal graphite precipitates, precipitates of carbides and mixed carbides as small grey crystals.

Photomicrograph 3, etched with HNO₃, magnification ×500, shows the bainitic-martensitic structure. The white crystals are again carbides or mixed carbides, while the large grey areas are formed by graphite.

WHAT WE CLAIM IS:—

1. A wear-resistant spheroidal-graphite cast-iron alloy having the following composition:—

	per cent by weight	
Carbon	2.5 —4.5	100
Silicon	1.5 —4.5	
Sulphur below	0.1	
Manganese	0.5 —1.7	
Phosphorus	0.06—0.5	
Chromium	0.2 —0.8	105
Vanadium	0.1 —2.5	
Nickel	0.2 —0.8	
Copper	0.2 —1.8	
Titanium	0.1 —0.8	
Tungsten	0.2 —2.0	110
Tin	0.05—1.0	
Magnesium	0.02—0.5	
Molybdenum	0.2 —2.0	
Niobium	0.2 —2.0	
Remainder	iron	115

2. An alloy as claimed in claim 1 modified by the addition of up to 0.5 per cent by weight in total of an element or elements selected from antimony, boron, zirconium, bismuth and the rare-earth metals.

3. A process of manufacture of the alloy of claim 1 or 2 in which the melt is inoculated with ferrosilicon and afterwards with mag-

nesium in an amount of 0.4 per cent by weight.

- 5 4. An alloy as claimed in claim 1 or 2 which has been heat treated by annealing above 700°C, quenching and then tempering between 200°C. and 700°C.

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FIG. 1

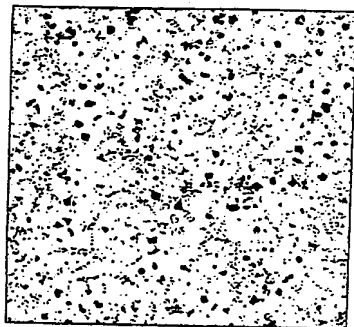


FIG. 2

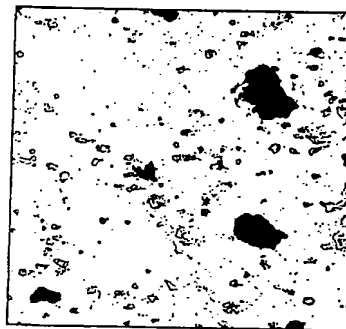


FIG. 3



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